

PROTAPES MOTSEI SP. NOV. (MOLLUSCA, VENERIDAE) FROM THE SOUTH COAST OF CHINA, AN OVERLOOKED BIVALVE SPECIES EVIDENCED BY ITERATIVE TAXONOMY

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Abstract An iterative analyses in 2011 evidenced that two cryptic species exist in nominal *Protapes gallus* along the southern coast of China. Herein, after examining additional specimens, stable diagnostic morphological characters were confirmed, and a new species, *P. motsei* Chen, Zhang & Kong, is described. Colour rays of the new species are extremely narrow and dusky, or even absent, and its zigzag streaks are weak, both features that are distinctly different from the original description of *P. gallus*. The new species is widely distributed along the southern coast of China.

Key words Veneridae, *Protapes*, DNA barcoding, iterative taxonomy, new species

INTRODUCTION

Morphological characters, as complex and non-neutral markers, need to be interpreted subjectively and so could lead to under- or over-estimation of species diversity (Lefébure *et al.*, 2006), especially for morphologically muddling and/or poorly understood taxa. Molecular methods have shown high effectiveness in resolution of species-level taxonomic problems. Recently, more and more integrated taxonomic studies, combining molecular and morphological characters, have been used to explore and document molluscan species-level biodiversity (e.g., Schniebs *et al.*, 2011; Kong *et al.*, 2012). Herein, an overlooked bivalve species, which is widely distributed along the southern coast of China, is described on the basis of iterative analyses using molecular and morphological data.

High genetic diversity was revealed in nominal *Protapes gallus* (Gmelin, 1791) along the southern coast of China in our previous DNA barcoding study (Chen *et al.* 2011), and the finding was confirmed by our subsequent analyses using multi-locus genes (Chen *et al.*, 2014; Fig. 1), suggesting that *P. gallus* reported from Chinese waters is a species complex. Although differences in conchological characters were found among cryptic species within the *P. gallus* complex in our previous studies, we were unable to determine their diagnostic value due to relatively small sample sizes. After examining additional specimens, stable

diagnostic morphological characters have been found, and the new species *P. motsei* is erected in the present study.

Type specimens were collected from the southern coast of China in 2011, and their soft parts were preserved in 95% ethanol for DNA analysis. Molecular information was obtained from our previous study (Chen *et al.*, 2014). Shells were photographed with a Nikon D80 digital camera. Additional shells of the genus *Protapes* deposited at Fisheries College, Ocean University of China, Qingdao, China (FCOUC) and the Marine Biota Museum of the Chinese Academy of Sciences, Qingdao, China (MBMCAS) were also examined; type specimens are deposited in these two repositories.

SYSTEMATICS

Family Veneridae Rafinesque, 1815

Subfamily Tapetinae H. & A. Adams, 1857

Genus *Protapes* Dall, 1902

Type species by original designation: *Venus gallus* Gmelin, 1791.

Diagnosis Shell ovate to subtrigonal, bilaterally compressed to inflated; Shell oval to subtrigonal; outer surface ornamented with concentric riblets; lunule impressed and ovate-lanceolate; posterior ventral margin twisted to left; hinge plate small; each valve with three weak cardinals; cardinals 1, 2a, 2b, and 3b bifid; pallial sinus deep and erect.

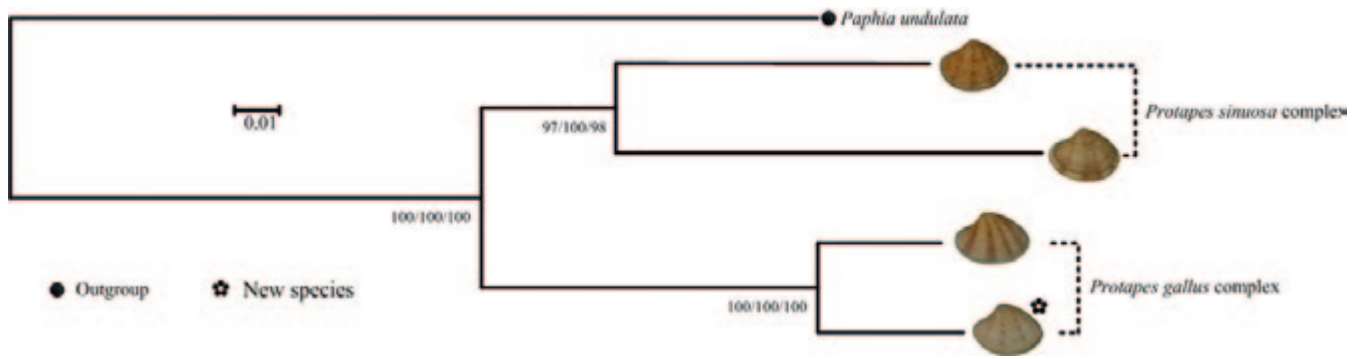


Figure 1 A Bayesian inference tree for *Protapes* collected from the coast of China, as inferred from combined nuclear and mitochondrial data, redrawn from Chen *et al.* (2014). Numbers near the nodes indicate Bayesian posterior probabilities/MP bootstrap percentages/ML bootstrap percentages.

Protapes motsei Chen, Zhang & Kong, new species
(Fig. 2A–L)

Holotype MBM119982 (MBMCAS), Jiaowei, Xuwen, Guangdong Province, China, 1 conjoined specimen, 6 April 2011, Coll. CHEN Jun.

Paratypes MBM119983 and MBM119984 (MBMCAS), Jiaowei, Xuwen, Guangdong Province, China, 2 conjoined specimens, 6 April 2011, Coll. CHEN Jun; JB110401–1 to JB110401–5 (FCOUC), Xichang, Beihai, Guangxi Zhuang Autonomous Region, China, 5 conjoined specimens, 10 April 2011, Coll. LIU Jun; JL110301–1 to JL110301–3 (FCOUC), Qishui, Leizhou, Guangdong Province, China, 3 conjoined specimens, 30 March 2011, Coll. CHEN Jun.

Etymology Named in honour of Mo-tse who made a significant contribution to Chinese culture as well as natural science.

Molecular information Six gene fragments of the holotype MBM119982 were deposited in GenBank, with the accession number JQ277807 for COI, JQ277754 for 16S, JQ277819 for H3, JQ277771 for 18S, JQ277746 for ITS1, and JQ277789 for 28S.

Description Shell medium in size, elongate oval to subtrigonal, compressed to somewhat inflated, inequilateral, and weakly twisted to the left postero-ventrally. Umbos tilted obliquely forward, situated at approximately the anterior 1/3 of the shell. Posterior margin narrowly rounded; ventral margin and anterior margin rounded. Shell sculpture of regularly spaced,

low, concentric riblets separated by shallow narrower grooves. Outer surface yellow to fawn in colour; zigzag streaks weak; four brown rays, extremely narrow, interrupted, dusky, or even completely absent. Lunule lanceolate, slightly concave, pale yellow to luminous yellow in colour. Escutcheon long, narrow, striated, and obscurely defined by blunt ridge running postero-dorsally from beak. Ligament brown, approximately 1/2 length of escutcheon. Inner margin smooth. Interior surface white, with reddish blush covering 1/2 to 1/3 of interior nearest umbo, beak cavity with purple rays. Hinge plate very narrow, with three cardinal teeth in each valve radiating from beak; lateral teeth absent; cardinals 1, 2b, 3b deeply divided, 2a shallowly bifid, 3a and 4 entire and very thin. Pallial sinus broad and directed antero-dorsally; remaining pallial line indistinct. Posterior adductor scar subcircular, larger than semicircular anterior scar.

Distribution Xiamen, Fujian Province and southward in seas of China.

Habitat Muddy sand bottom of the lower intertidal and shallow subtidal zones.

Remarks The colour rays of the new species are extremely narrow and dusky, or even completely absent, and its zigzag streaks are weak, both of which are distinctly different from the original description of *P. gallus* (Chemnitz, 1782) (see also Gmelin, 1791). The other morphotype with four broad rays in the *P. gallus* complex revealed by our previous studies (Chen *et al.*, 2011, 2014), is likely to be *P. gallus* described by Gmelin (1791) (Fig.

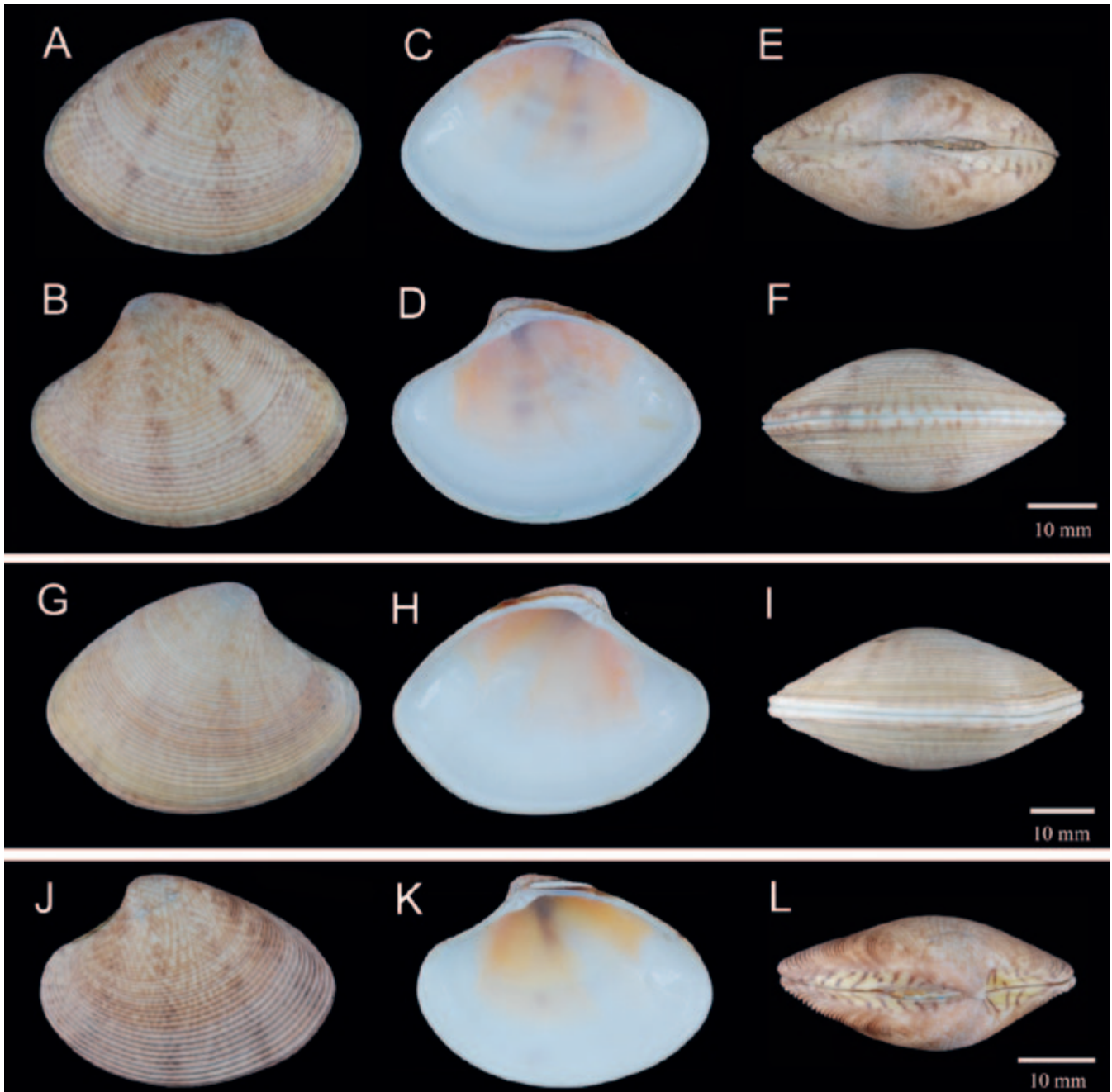


Figure 2 *Protapes motsei* sp. nov. A–F, Holotype, MBM119982; A, right valve; B, left valve; C, inside view of left valve; D, inside view of right valve; E, dorsal view of conjoined valves; F, ventral view of conjoined valves; G–I, paratype, MBM119982; G, right valve; H, inside view of left valve; I, ventral view of conjoined valves; J–L, paratype, MBM119982; J, left valve; K, inside view of right valve; L, dorsal view of conjoined valves.

3). However some of its conchological characters are also somewhat different from the original description of *P. gallus*, so this conclusion needs to be confirmed by checking type specimens or topotypes from the Malabar Coast. After checking *Protapes* specimens deposited in FCOUC and MBMCAS, we found that the new species has been collected in many sampling sites in

Xiamen of Fujian Province, Shantou, Yangjiang, Zhanjiang, Leizhou, Xuwen of Guangdong Province, Beihai, Qinzhou of Guangxi Zhuang Autonomous Region, and Wenchang, Lingao of Hainan Province (Fig. 4). Therefore, this species is widely distributed along the southern coast of China, extending into the tropical western Pacific.

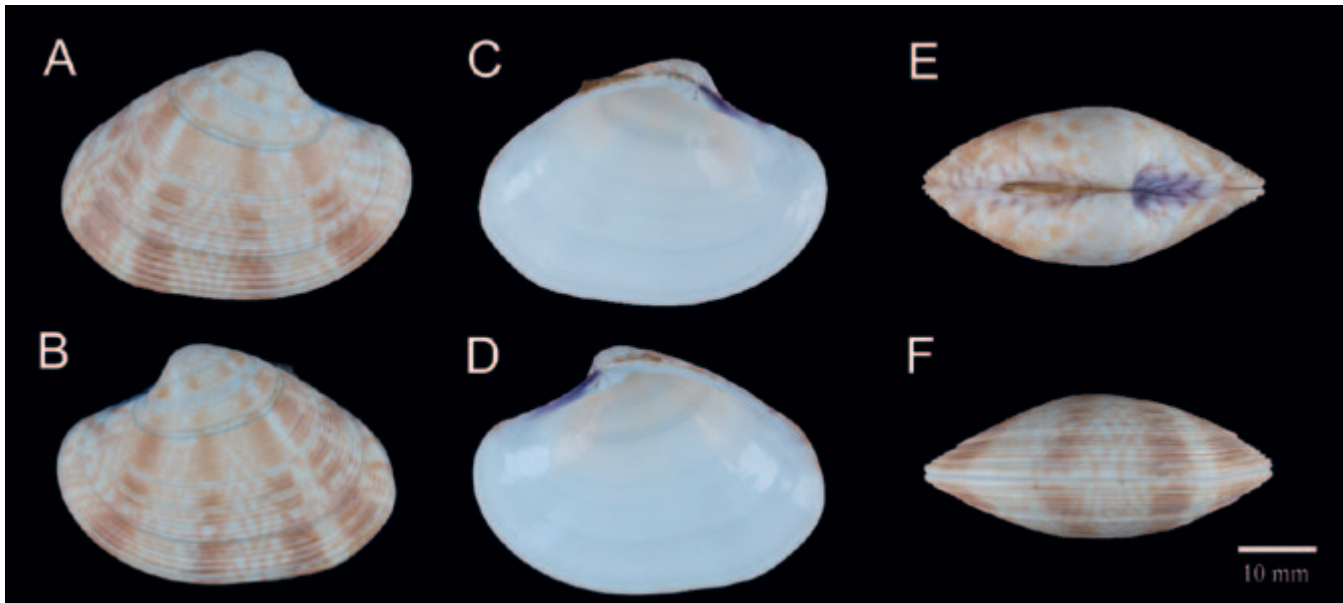


Figure 3 *Protapes gallus?* collected from Pingtang, Fujian (MBM119325). **A**, right valve; **B**, left valve; **C**, inside view of left valve; **D**, inside view of right valve; **E**, dorsal view of conjoined valves; **F**, ventral view of conjoined valves.

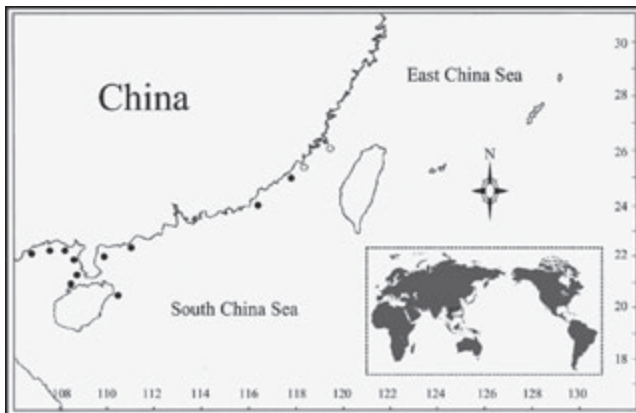


Figure 4 Geographical distribution of *Protapes motsei* sp. nov. (indicated by solid circles) and *P. gallus?* (indicated by hollow circles) based on materials examined in this study.

DISCUSSION

Cryptic diversity within *P. gallus* (as conventionally understood) was revealed in our DNA barcoding study (Chen *et al.*, 2011), and two independent evolutionary lineages (i.e., species) were confirmed by our subsequent iterative analyses using multi-locus gene makers (Chen *et al.*, 2014). Our iterative taxonomic studies (Chen *et al.*, 2011; Chen *et al.*, 2014; study presented herein) based on molecular and morphological data suggest that *P. motsei* is a real biological species, and so the new species *P. motsei* is described herein

because some stable diagnostic morphological characters were confirmed by examining specimens deposited in FCOUC and MBMCAS.

Nominal *Protapes gallus* is widely distributed in Indo-West Pacific Region, ranging from the Malabar Coast of south-west India to the Philippines and northern Australia (Matsukuma *et al.*, 1988; Oliver & Glover, 1996). Much taxonomic literature (e.g., Sowerby, 1852; Oliver & Glover, 1996; Zhuang, 2001) have reported that this nominal species exhibits multiple morphological types. However, all of these morphological types were previously treated as intraspecific variation instead of interspecific isolation. The widely distributed new species is overlooked and long treated as intraspecific variation of *P. gallus* in Chinese taxonomic literature. Hence, our studies indicate that iterative analyses based on molecular and morphological data is effective in species exploration, investigation, and documentation.

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